WEATHERING TEST OF FURFURYLATED WOOD DECKS IN A 3-YEAR EXPOSURE IN GREECE

George Mantanis[1] and Charalampos Lykidis[2]

[1] TEI of Thessaly, Dept. of Wood & Furniture Design and Technology, Research Lab of Wood Science and Technology, Karditsa, Greece, mantanis@teithessaly.gr

[2] Hellenic Agricultural Organisation "Demeter", Forest Research Institute of Athens, Lab of Wood Anatomy and Technology, Athens, Greece, lykidis@fria.gr

COST Action FP1303 – 1st Conference, 'Performance and maintenance of bio-based building materials influencing the life cycle and LCA', Kranjska Gora, Slovenia, 23 & 24 October 2014

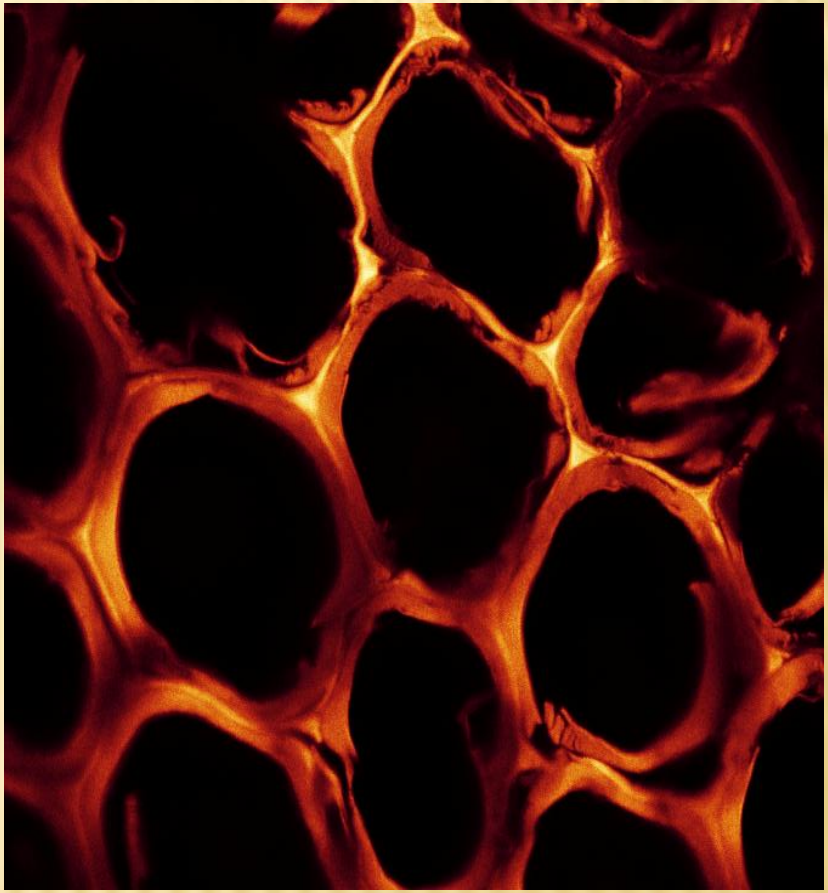
Aim of the work

In this work, a **three-year natural weathering test** of **furfurylated wood decks** was carried out in Greece.

The wood decks (without any protection or finishing) were exposed outdoors for **36 months** in order to evaluate physical and structural properties such as colour, staining, distortions, surface cracking and end-splitting.

FURFURYLATION OF WOOD

- In the furfurylation process, the bio-based chemical, **furfuryl alcohol** is impregnated into the wood cell wall structure, and subsequently polymerised to **furan polymers** that are "grafted" to the cell walls.
- These polymers are very stable, and will not degrade or leach out of the wood.
- The presence of furan polymers in the cell walls **blocks partly the cell walls' ability** to absorb water, and leads to **reduced shrinkage and swelling**.



- Cross section of Radiata pine; cell walls containing furan polymer, image through fluorescence microscopy (L. Garbrecht Thygesen, RVAU, Copenhagen, 2006).
- Fluorescence caused by furan polymer
- Cell walls are invisible in this system without the fluorescence from the polymer

Courtesy by KEBONY AS

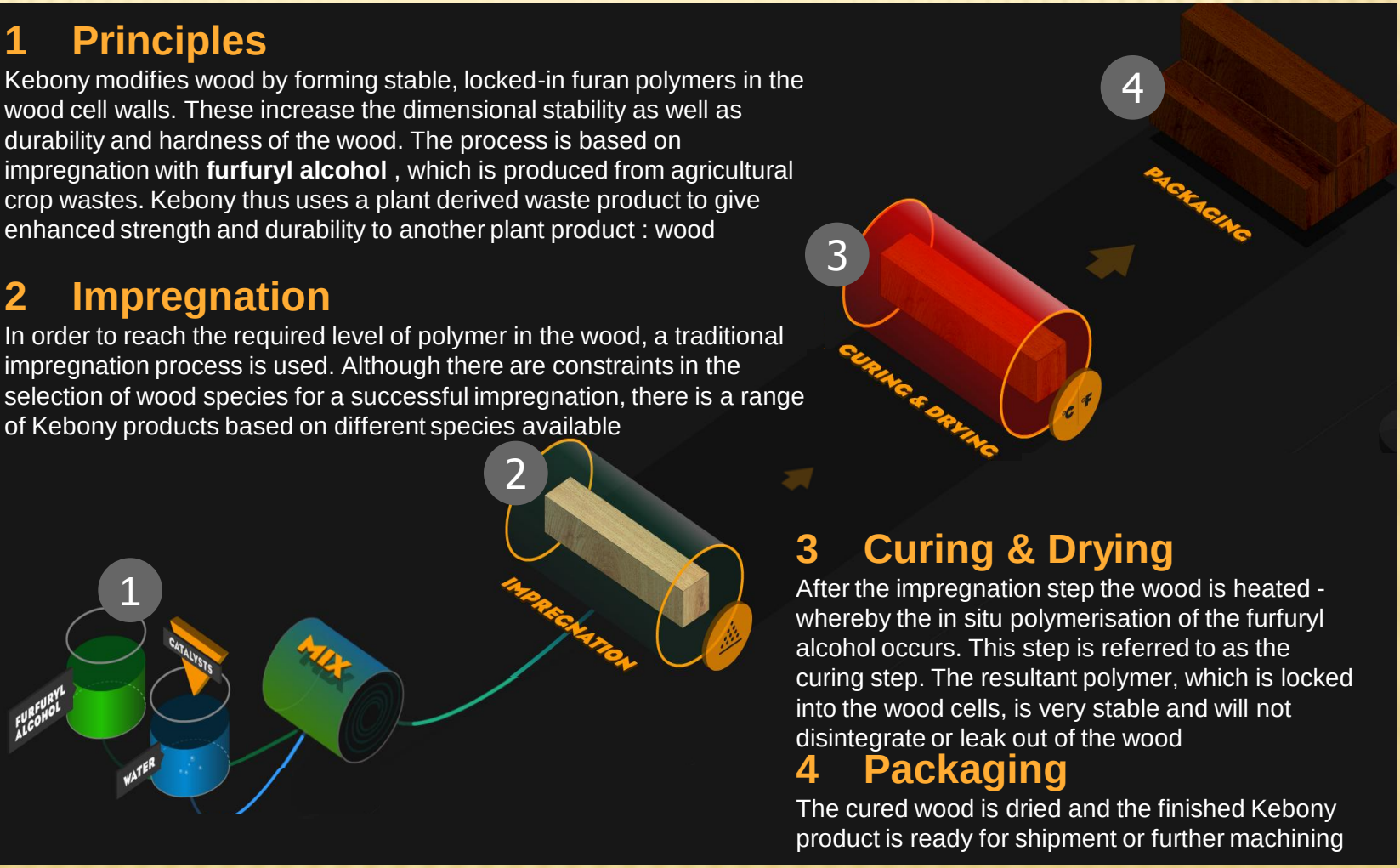
THE KEBONY PROCESS

1 Principles

Kebony modifies wood by forming stable, locked-in furan polymers in the wood cell walls. These increase the dimensional stability as well as durability and hardness of the wood. The process is based on impregnation with **furfuryl alcohol** , which is produced from agricultural crop wastes. Kebony thus uses a plant derived waste product to give enhanced strength and durability to another plant product : wood

2 Impregnation

In order to reach the required level of polymer in the wood, a traditional impregnation process is used. Although there are constraints in the selection of wood species for a successful impregnation, there is a range of Kebony products based on different species available



3 Curing & Drying

After the impregnation step the wood is heated - whereby the in situ polymerisation of the furfuryl alcohol occurs. This step is referred to as the curing step. The resultant polymer, which is locked into the wood cells, is very stable and will not disintegrate or leak out of the wood

4 Packaging

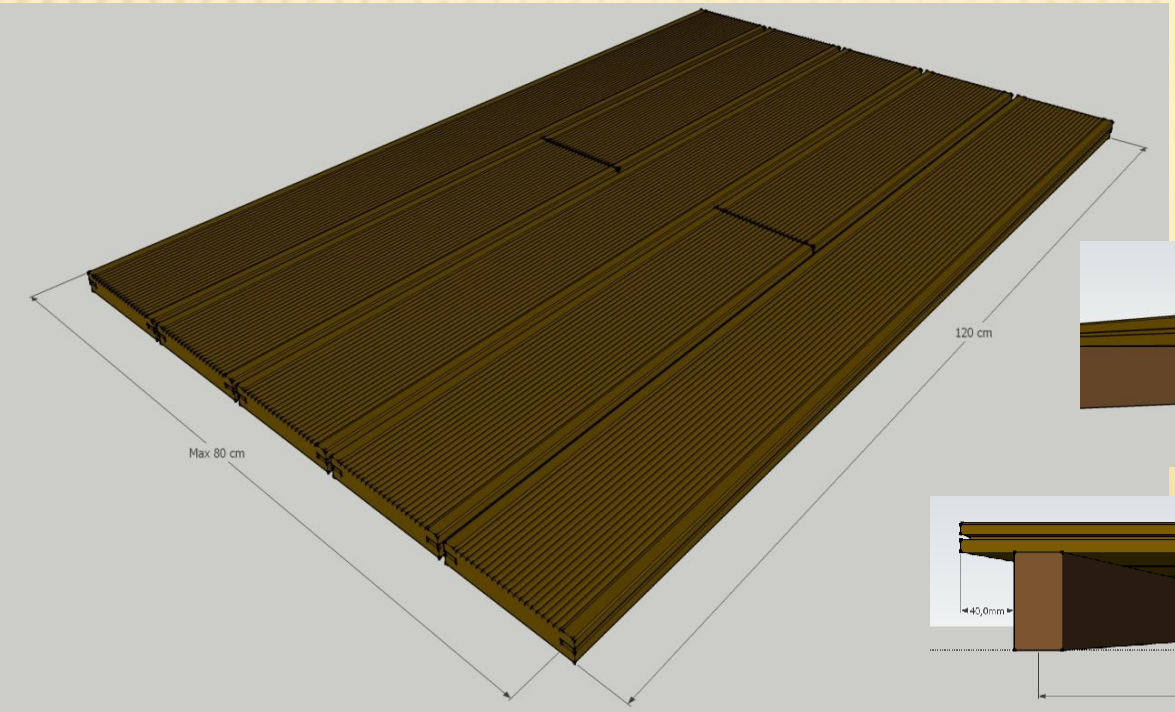
The cured wood is dried and the finished Kebony product is ready for shipment or further machining

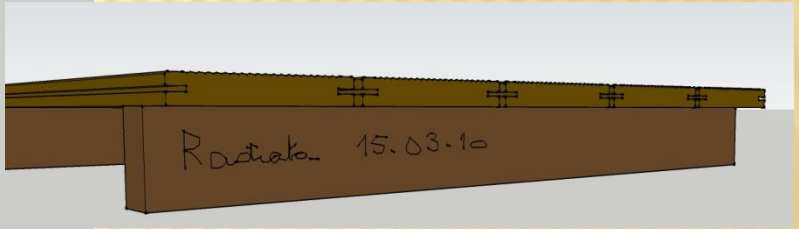
Photos : KEBONY AS

Furfurylated wood in outdoor applications in Norway

Material and methods

- Decks of **furfurylated Radiata pine** (Pinus radiata)
- Decks of **furfurylated Maple** (Acer spp.) wood, both delivered to Greece by company Kebony AS, and
- One **control deck of Ipê** (Handroanthus spp.) wood deck that was used for comparison reasons.

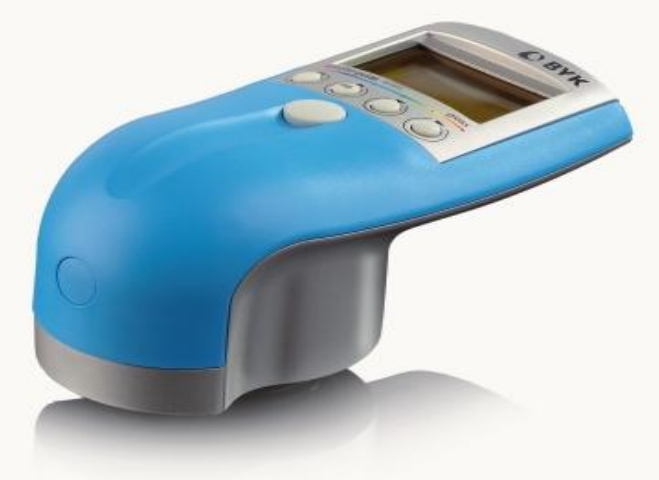




Wood deck materials (as in May 2011)

a) Colour changes

- Applying the **CIELAB colour system**, the colour parameters **L*** (lightness), **a*** (redness) and **b*** (yellowness) were determined. For each of the wood decks and for each weathering sub-period (month: 6th, 12th, 24th, 36th)



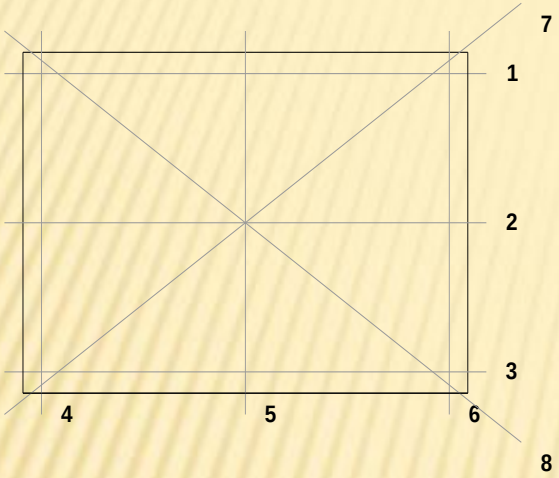
◯ 1	7 ◯
◯ 2	8 ◯
◯ 3	9 ◯
◯ 4	10 ◯
◯ 5	11 ◯
◯ 6	12 ◯

b) Black staining

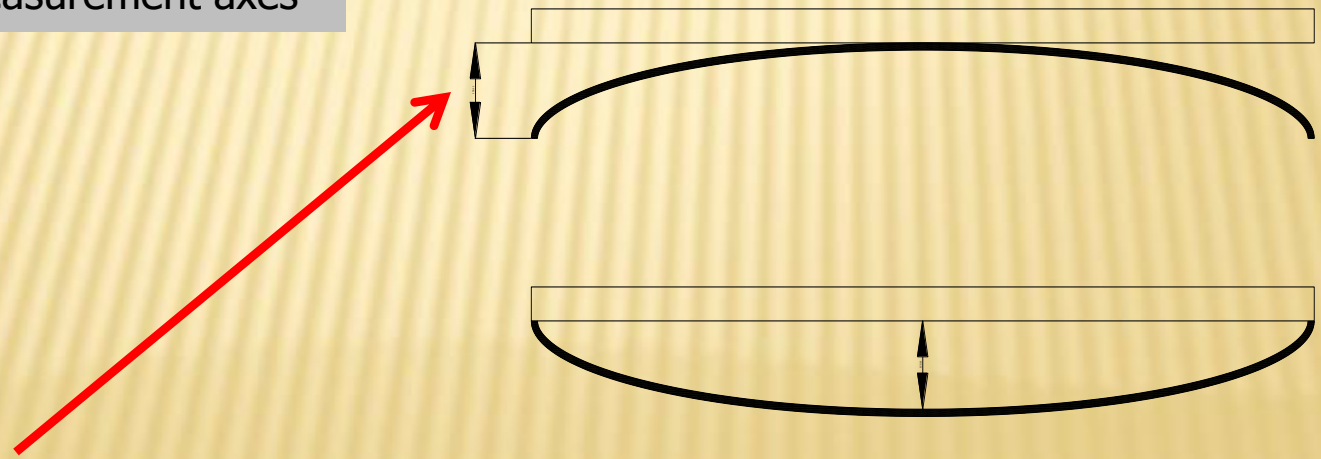
- Evaluation of black staining was made by **naked eye**.

c) Distortion

- **The distortions in wood decks were estimated with a dial caliper over the width of each deck**



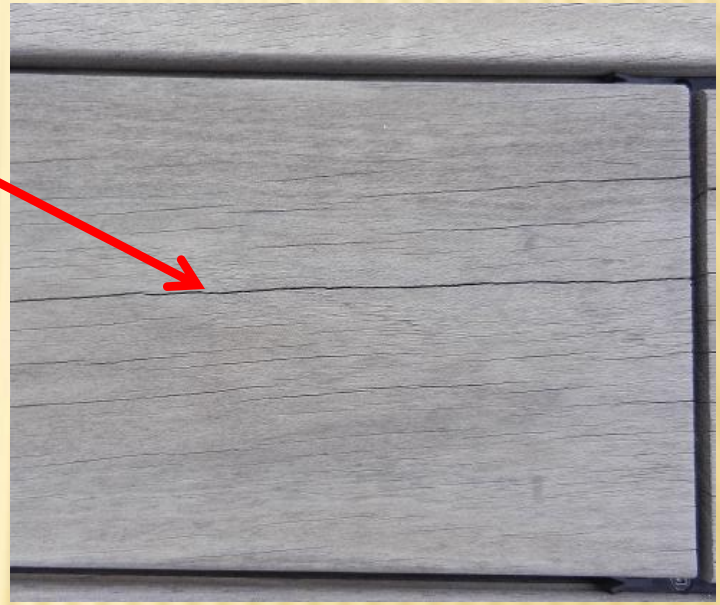
Distortion measurement axes



Determination of distortion as measured in each wood deck tested
(up: **negative** distortion values; down: **positive** distortion values)

d) Cracking

- Initial control for cracks was made in all tested materials and **photographs** were taken. Every year the decks were carefully checked by naked eye. Photographs were taken for comparative reasons.



e) End-splitting

- In regard to end-splitting, **this was examined periodically**, while corresponding photographs were taken.

Results

- All decks tested exhibited an extensive **greying effect** in their surfaces.

Furfurylated wood decks as appeared in May 2014

FF R. Pine (as in May 2011)

FF R. Pine (as in May 2014)

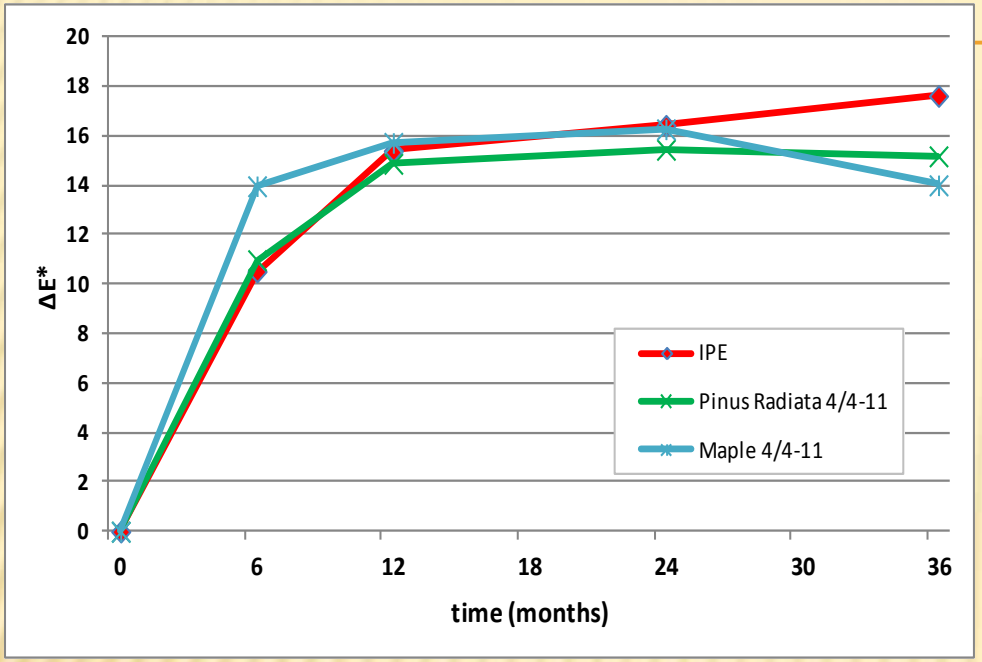
FF Maple (as in May 2011)

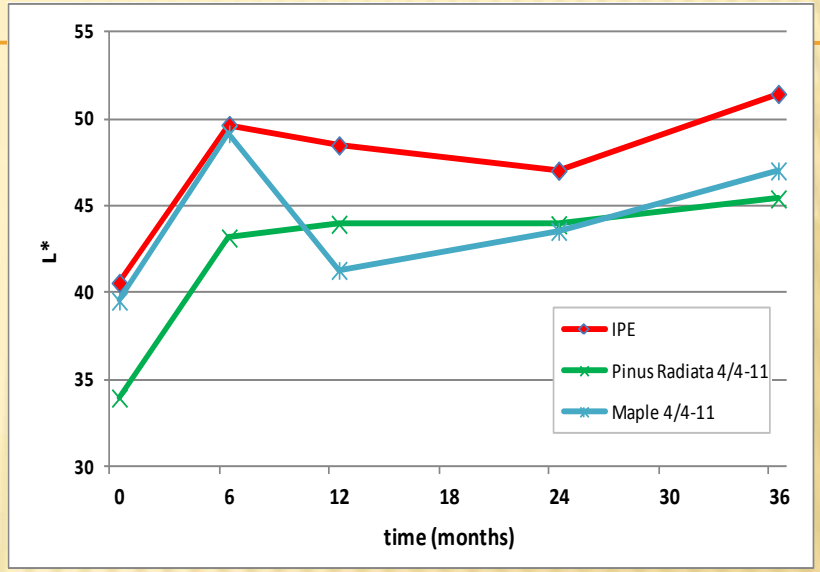
FF Maple (as in May 2014)

Ipê deck (as in May 2011)

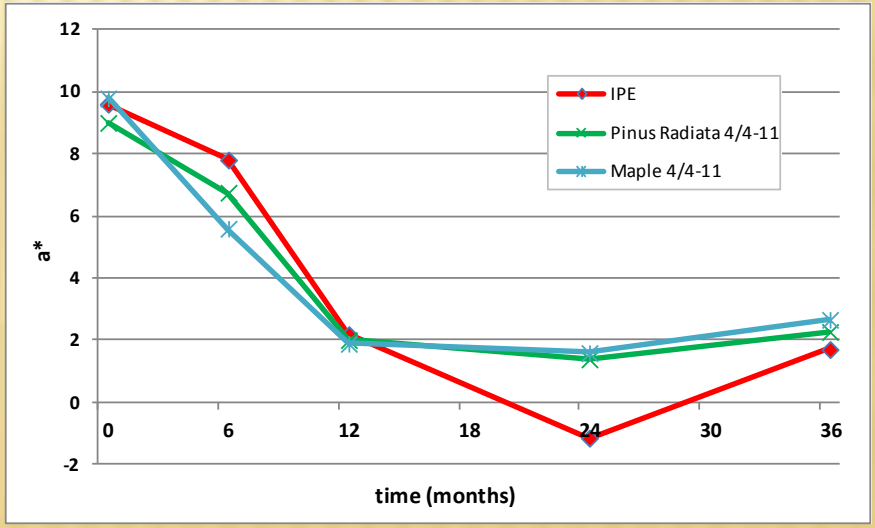
Ipê deck (as in May 2014)

Colour changes



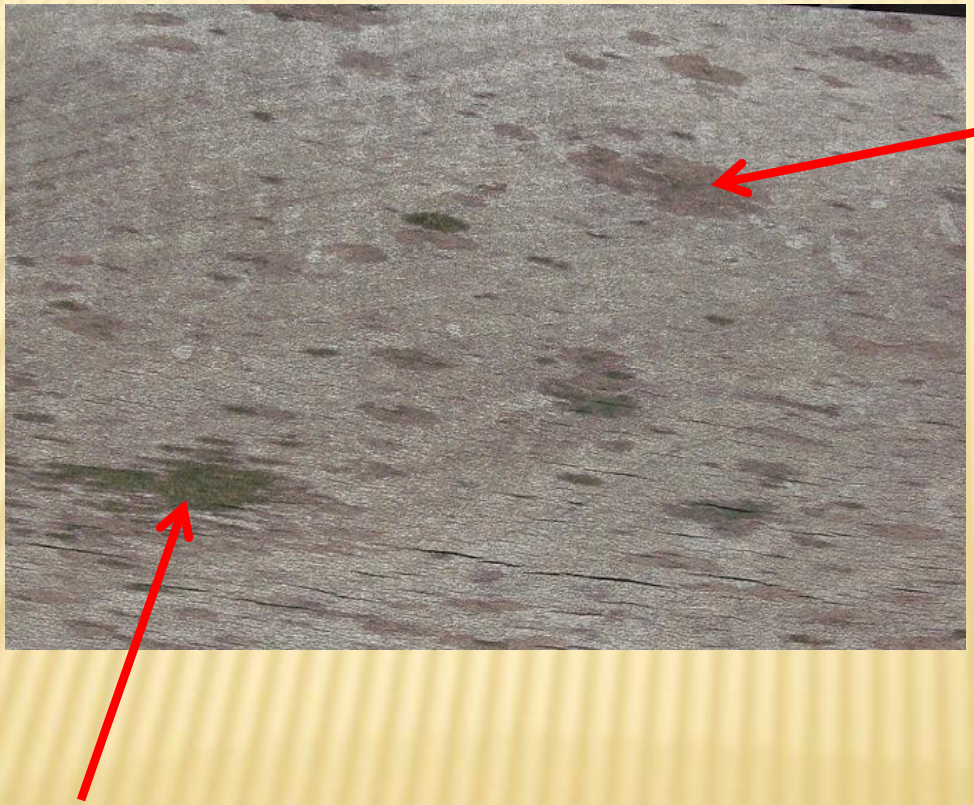


- Colour changes were intense during the first 12 months.
- All wood decks showed reduction of redness but still in positive values (a*)
- After 12 weathering months, all decks showed additional yellowness reduction.



Black staining

- **No black staining -** except for the FF Maple decks which showed some mild **shadow spots** on wood surfaces.



Distortions

Dirtortions in measurement axes	Ipê deck (mm)	Furfurylated R. Pine deck (mm)	Furfurylated Maple deck (mm)
1	1.82	1.78	1.02
2	1.63	2.60	1.18
3	1.46	3.22	1.44
4	1.37	0.50	1.63
5	3.98	0.35	0.94
6	0.21	2.51	2.46
7	2.28	1.43	0.16
8	7.06	3.95	2.26

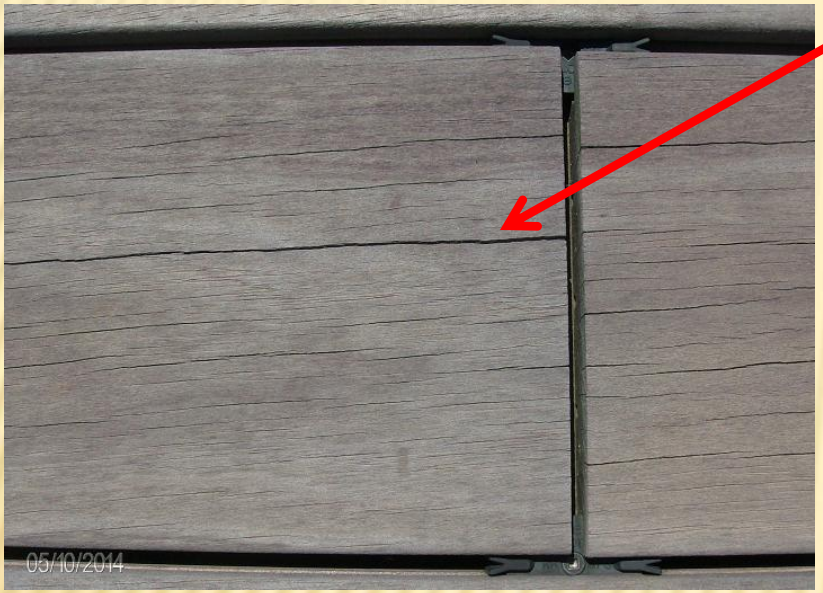
: Intense distortion

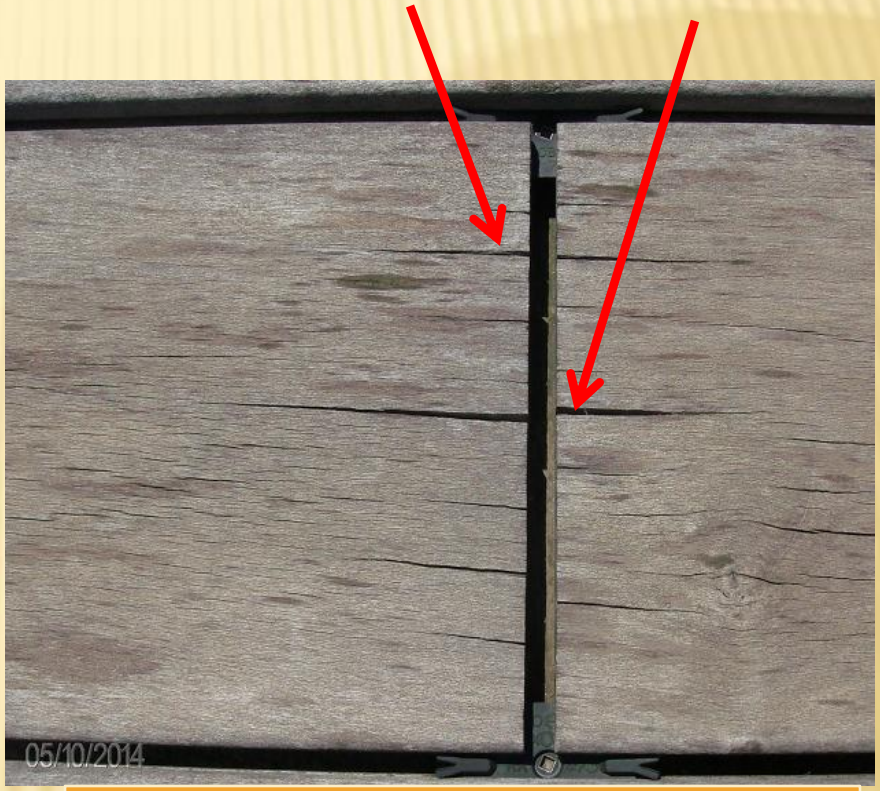
: Minimal distortion

- The most distorted one was that of Ipê wood deck. **The least distorted decks were the FF maple decks** followed by the FF radiata pine decks.

Cracking

- **Ipê wood** deck showed to have the minimum number of cracks on its surface, closely followed by the Radiata pine wood deck which had only a very few small cracks.



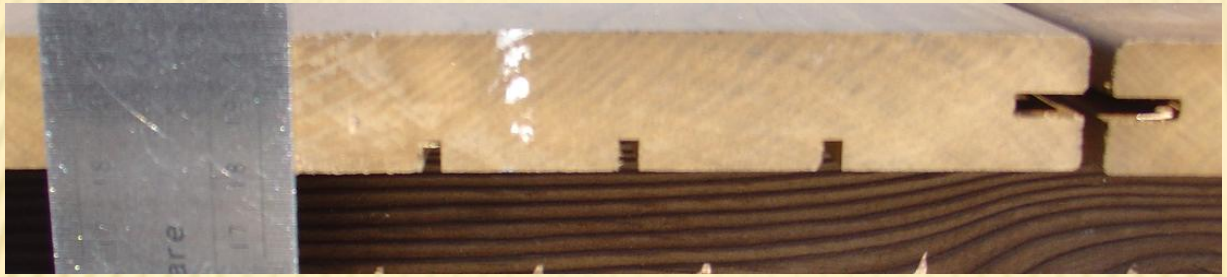


FF Maple (as in May 2014)

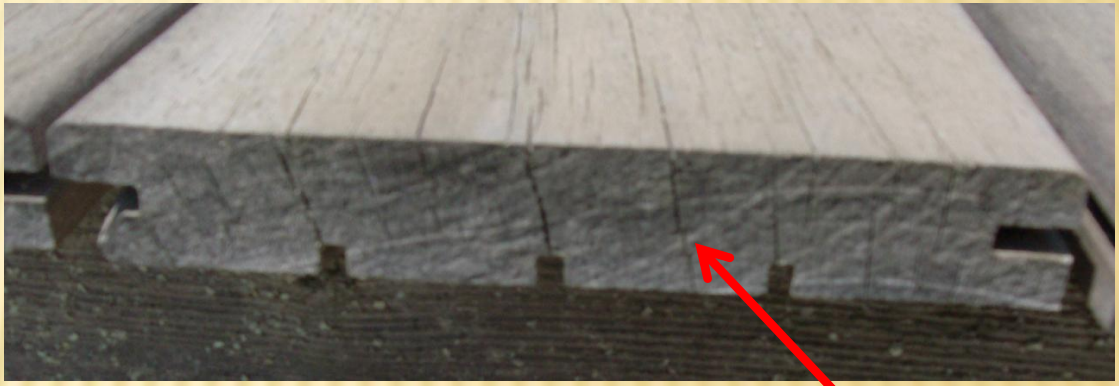
FF Rad. Pine (as in May 2014)

End-splitting

A) It appeared that the furfurylated **Radiata pine decks** showed the **mildest end-splitting**



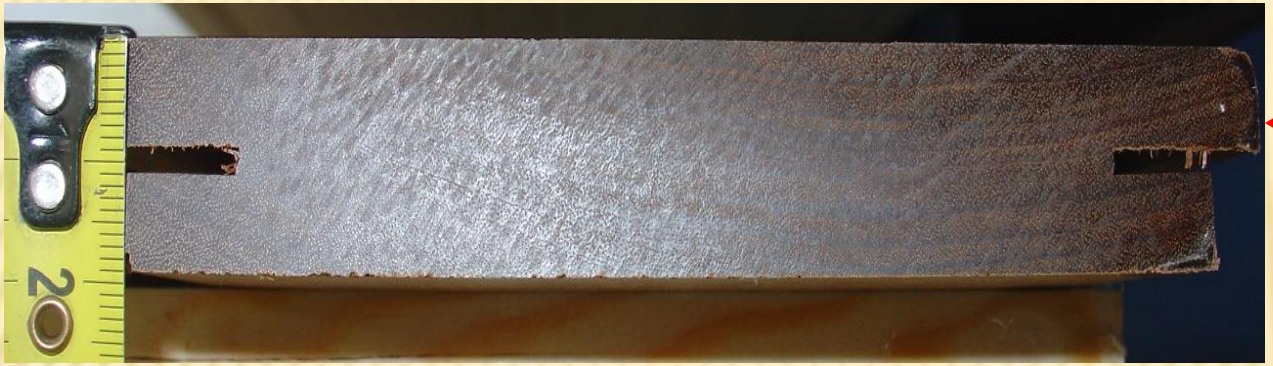
As in May, 2011



FF Radiata Pine decks

End-splitting

B) The control **Ipê decks** showed some degree of **end-splitting**



As in May, 2011

Control Ipê wood decks

End-splitting

C) It appeared that the furfurylated **Maple wood decks** showed a **higher degree** of end-splitting

As in May, 2011

FF Maple wood decks

Conclusions

- All tested decks showed **colour changes that were perceptible** by the human eye and were much higher during the first 12 months and much lower during the following ones.
- The furfurylated decks showed smaller total colour changes compared to the control deck of Ipê wood.
- Concerning cracking and end-splitting, furfurylated Radiata wood decks **presented the lowest degree of surface and edge cracking**.
- All wood decks tested along with the control Ipê wood deck have showed **no signs of staining or decay** after three years of outdoor exposure. The experiment continues ...

COST FP1303
Performance of bio-based building materials

Thank you for your attention!